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DATA TRANSMISSION IN AUTOMATED MASS SERVICING SYSTEMS,(U)

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by

Yu.M. Vinogradov, V.Ye. Khazatskiy

EDITED TRANSLATION

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А а	*А а*	A, a	Р р	*Р р*	R, r
Б б	*Б б*	B, b	С с	*С с*	S, s
В в	*В в*	V, v	Т т	*Т т*	T, t
Г г	*Г г*	G, g	У у	*У у*	U, u
Д д	*Д д*	D, d	Ф ф	*Ф ф*	F, f
Е е	*Е е*	Ye, ye; E, e*	Х х	*Х х*	Kh, kh
Ж ж	*Ж ж*	Zh, zh	Ц ц	*Ц ц*	Ts, ts
З з	*З з*	Z, z	Ч ч	*Ч ч*	Ch, ch
И и	*И и*	I, i	Ш ш	*Ш ш*	Sh, sh
Й й	*Й й*	Y, y	Щ щ	*Щ щ*	Shch, shch
К к	*К к*	K, k	Ъ ъ	*Ъ ъ*	"
Л л	*Л л*	L, l	Ы ы	*Ы ы*	Y, y
М м	*М м*	M, m	Ь ь	*Ь ь*	'
Н н	*Н н*	N, n	Э э	*Э э*	E, e
О о	*О о*	O, o	Ю ю	*Ю ю*	Yu, yu
П п	*П п*	P, p	Я я	*Я я*	Ya, ya

*ye initially, after vowels, and after ъ, ь; e elsewhere.
When written as ë in Russian, transliterate as yë or ë.

RUSSIAN AND ENGLISH TRIGONOMETRIC FUNCTIONS

Russian	English	Russian	English	Russian	English
sin	sin	sh	sinh	arc sh	$\sinh^{-1}$
cos	cos	ch	cosh	arc ch	$\cosh^{-1}$
tg	tan	th	tanh	arc th	$\tanh^{-1}$
ctg	cot	cth	coth	arc cth	$\coth^{-1}$
sec	sec	sch	sech	arc sch	sech^{-1}
cosec	csc	csch	csch	arc csch	csch^{-1}

Russian	English
rot	curl
lg	log

1911

DATA TRANSMISSION IN AUTOMATED MASS SERVICING SYSTEMS

Yu. M. Vinogradov, V. Ye. Khazatskiy.

We examined the specific features and described the operating principles of the data transmission apparatus for automated mass servicing systems, in which information is assembled and processed by a computer.

The creation of automated mass servicing systems (ASMO) is one of the urgent problems of modern technology. Systems of such type are constructed on the basis of the connection of communication networks of servicing places with a central storage and processing unit - computer (VM). In the article are examined the principles of construction of the data transmission equipment (APD), which accomplishes transmission of information along communication lines from an automatic device, installed at the subscriber, to the central VM, which, in turn, transmits the processed information to the

subscriber.

Similar systems are applied abroad. One of the first in 1945 was the introduced system of reservation of seats on the Pennsylvania railroad (USA). The communication of subscribers with the computer was accomplished by leased telegraph channels with the aid of teletypes.

Similar systems MARS-101 and MARS-102 are used in Japan for seat reservation on railroad transport. The channels in these systems are also telegraph, formed by means of secondary multiplexing of telephone channels of high-frequency radio-relay communication.

In Copenhagen there is a system of reservation of seats on a ship with servicing points, located on the territory of Denmark and FRG. The specialized telegraph equipment for this system is made by the firm Siemens-Galske (FRG). The system Transdata-8064 of this firm is intended for the reservation and sale of railroad tickets both with direct transmission of orders to VM and through switchboards of communication channels. The information is transmitted at low speeds (50 baud), is accumulated at an intermediate point and then at high speed (1200-2400 baud) is transmitted to VM.

At present in the USSR AMSO of such type are constructed for

reserving and sale of tickets on aircraft and long distance trains (systems "Sirena-1" and "Ekspress"). So far only the return of tickets by the Moscow stations (for example, in 1968) comprised 1.4 o/o. The overall underloading of trains and aircraft due to disagreement of the work of return and reservation booths and large losses of time for the purchase of tickets reaches 2-5 o/o, which leads to economic losses, comprising several millions of rubles per year. Putting the indicated systems into service will contribute to the elimination of the indicated deficiencies and will give a great economical effect due to increase of the loading of long-range transport and substantial acceleration of the servicing of passengers.

The development of ASMO is possible for hospitals, where the distribution of beds will be centralized, by means of conversion to common computer. This computer will take on the problem of accounting calculations for service. With further growth of the level of servicing such systems can be applied for centralized order of merchandise and service from special points, equipped with equipment for the transmission of information to VM, and also for connection with the aid of special portable devices through the communication network with diagnostic and reference VM.

Hierarchic structure and special mode of operation are

characteristic for ASMO. The subscriber at the point with the aid of a specialized device for input and transmission of information (AU) is connected to the VM and along the communication channel transmits the request for servicing, containing coded information. After calculation and determination of data for servicing the VM transmits the response along the communication channel (enters the automatic subscriber device).

The APD for ASMO should economically use the channels, should possess sufficient quick operation and provide high reliability of transmission. Since the character of the next interrogations and responses to ASMO is random, then this, in turn, leads to the requirement of transmission of nonuniform volumes of information both to VM and to the servicing point. The block diagram of algorithm of operation of ASMO in the interrogation-response mode is presented in Fig. 1.

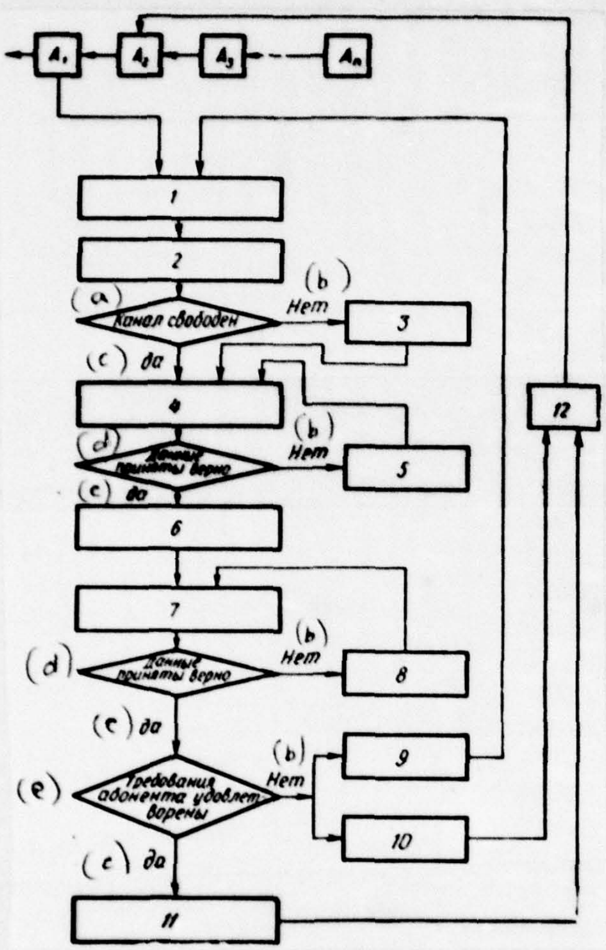

Fig. 1. Block diagram of algorithm of servicing of order (A_1, A_2, ..., A_n - subscribers of ASMO):

1 - input of order to AU; 2 - interrogation of communication; 3 - waiting of communication; 4 - transmission of data to VM; 5 -

interrogation of correction; 6 - processing of data in VM; 7 - transmission of data to subscriber; 8 - interrogation of correction; 9 - change of order; 10 - refusal of order; 11 - calculation with subscriber; 12 - shift of queue.

Key: (a) Channel is free. (b) No. (c) Yes. (d) Data are taken correct. (e) Requirements of subscriber are satisfied.

As seen from Fig. 1, the total servicing time T_0

$$T_o = \sum_{i=1}^{10} \Delta t_i, \qquad (1)$$

where Δt_i - time of execution of i operation of servicing algorithm.

Besides the above-discussed requirements, into the problem of data transmission system for ASMO enters minimization of time parameters of the servicing algorithm: $\Delta t_3, \Delta t_5, \Delta t_8$.

In contempory ASMO the reaction time of the system

$$T_{p.c.} = \sum_{i=2}^{8} \Delta t_i. \qquad (2)$$

should not exceed 1-4 s during operation on telephone communication channels and 10-20 s during operation on telegraph communication channels. The uncertainty of reception of information should be no worse than 10^{-6} per digit (digit - eight bits). The length of order

or response is measured from 5-6 to 256 digits. Besides the indicated, on the device of information transmission to ASMO are imposed rigid requirements on the part of its cost.

For transport ASMO the flow of requests (orders of tickets) is usually partially determined, but on relatively short time segments it can be approximately described by Poisson distribution [1].

The flow of errors in the communication channel, affecting the technical speed of transmission of information and the reliability, as investigations of recent years have shown, is nonstationary. It is poorly described by existing mathematical models, in view of which for calculation of technical speed and reliability there are used distributions, approximating the real data by means of selection of a number of coefficients.

In the State All-Union Central Scientific Research Institute of Complex Automation (TsNIIKA) for the system of reservation and sale of airplane tickets there is developed data transmission equipment of type APD-2. This device makes it possible to perform transmission over telephone communication channels with speeds 600 or 1200 baud and over telegraph channels with speeds 50, 75, 100 and 200 baud.

The algorithm of operation of APD is identical for all speeds.

The subscriber at the servicing point PO (Fig. 2) on the keyboard of a specialized manipulator gathers the information of the order and then feeds the request to servicing.

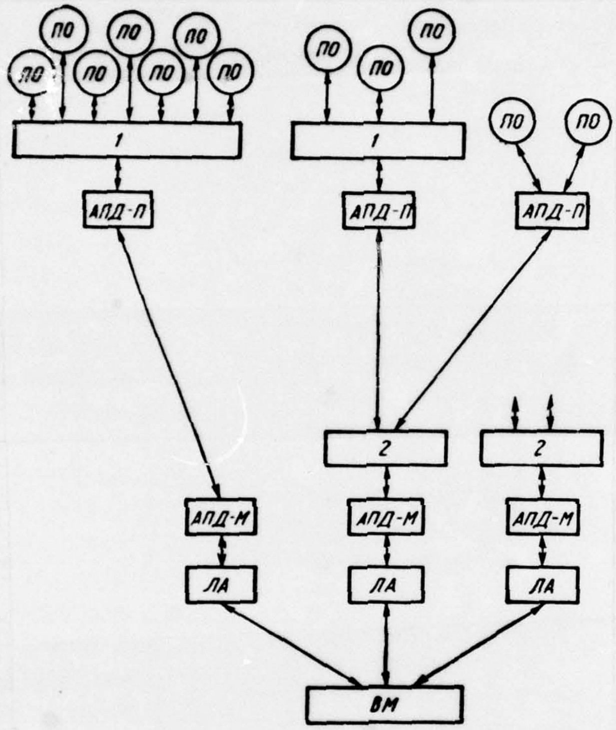

Fig. 2. Structural diagram of ASMO: 1 - commutator; 2 - concentrator.

The commutator questions the successive group of PO and connects the inquiring PO to the APD (APD-P), which, in turn, is connected through the concentrator or directly to the APD-M, installed on the side of the VM; the APD-M with the aid of the concentrator questions the APD-P and, going into synchronism, analyzes the code, sent by APD-P. If the APD-P sends code GP ("ready for reception"), then the APD-M is

switched to another device. If the APD-P sends code GPD ("ready for transmission"), then the APD-M remains connected to the APD-P until termination of the session of exchange.

For the APD of ASMC there is taken the operation over communication channel in the mode of operational half-duplex, with which after the transmission of information in one direction the code of permitting feedback is sent over the wide-band channel at the same speed in the opposite direction, for which commutation of the channel is performed. The application of operational half-duplex made it possible to considerably simplify the channel-forming device and to raise the quality of transmission due to the best use of the frequency range of the telephone channel.

With the presence of interrogation for servicing the APD-P sends the code GPD, and in the next cycle after reception from the APD-M of the code GP - code "start", order information and correcting digits KP (Fig. 3, a).

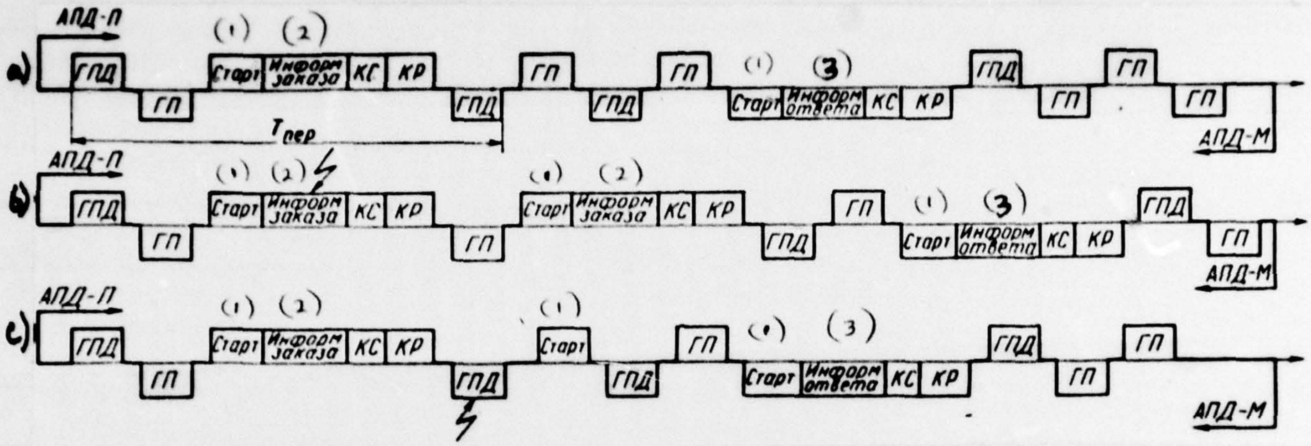

Fig. 3. Time diagram of exchanges of signals in APD.

Key: (1) Start. (2) Order information. (3) Response information.

The information part, as was indicated earlier, has variable length. For detection of the end of communication following the last informational digit there is transmitted the digit "end of communication".

The informational part of the block is introduced into the input memory of VM - linear adapter (LA). After checking the received information in the reliability raising device of APD-M and with detection of error - GP ("incorrect"). With the correct reception of information in VM the APD sends to the line coded combinations GPD ("correct"), and with detection of error - GP ("incorrect"). With

correct reception the order is processed by VM, and all this time the APD-M sends the code GPD. After termination of order processing the APD-M instead of the next code GPD sends code "start" and response information. The response is controlled by APD-P. To the manipulator, as to the VM, is sent the signal "correct" with simultaneous sending of code GPD to the line. With distortion of information there is sent code GP, after which the entire block of order or response is repeated (Fig. 3, b).

The reception and decoding of command codes occur at a definite moment of time. In case of distortion of command codes one of the devices, being the driving (APD-P), not having received signals from the driven device (APD-M), repeats the earlier sent command. This command is decoded in the APD-M, which also answers the earler decoded communications. If after the transmission of information there was not received signal "correct" (GPD) or "incorrect" (GP), code "start" is sent with information (Fig. 3, c). This makes it possible to reduce the losses on requestioning. Further after decoding of command codes at a certain moment of time the normal operating mode is restored.

For raising the reliability during reception of information in APD there is used excess coding with the application of cyclic codes (polynomial of fifteenth step), revealing all the single, double and

triple errors, and from the errors of higher multiplicity - all the uneven. Besides, these codes reveal "packs" of adjacent errors of multiplicity up to 15. This makes it possible to provide the probability of false reception of digit less than 10^{-6} with the probability of distortion of sendings in the communication channel $P_0=10^{-3}$.

The command codes are selected taking into account their decoding with random time of reception. These codes are obtained from pseudorandom Barker sequences by means of their mutual modulation and summation. They make it possible to detect all the errors, up to four-fold inclusively. The high reliability of reception of command codes made it possible in APD to apply correction of single errors, which raises the average technical speed and reduces the time of servicing.

As was noted above, one of the most important characteristics of ASMO is the reaction time of the system. Let us determine the total average reaction time of the system when servicing one subscriber.

The reaction time of the system taking into account operation of the commutator will be:

$$T_{\text{р. с. к}} = T'_{\text{ож}} + \mu'_1, \qquad (3)$$

where $T'_{\text{ож}}$ - average waiting time on the commutator for one servicing point.

μ'_1 - average time of one session of exchange.

The waiting time for steady-state process is determined:

$$T'_{\text{ож}} = \frac{\alpha'\mu'_2}{2(1-\alpha')\mu'_1}, \qquad (4)$$

where μ' - mathematical expectation of the square of the time of one session of exchange;

α' - probability of commutator being busy.

For simplification let us take dispersion equal to zero, then in accordance with [2]

$$\mu'_2 = (\mu'_1)^2.$$

Hence

$$T'_{\text{ож}} = \frac{\alpha'\mu'_1}{2(1-\alpha')}. \qquad (5)$$

α' is determined by formula

$$\alpha' = \lambda n_1 \mu'_1, \qquad (6)$$

where λ - average intensity of the flow of orders, entering the

manipulators;

n_1 - quantity of manipulators, serviced by one APD-P (let us accept that the manipulators service an identical number of manipulators).

Taking into account the rate of employment of concentrator the time of waiting is increased m times.

$$\alpha'' = m\alpha', \quad (7)$$

where $m = \frac{n_2}{n_1}$.

Here n_2 - quantity of manipulators, serviced by one APD-M, m - coefficient, characterizing the economy of the number of APD-M devices.

μ_1' is determined by formula

$$\mu_1' = T_{BM} + T_{\text{пи}} + T_{\text{кор}}, \quad (8)$$

where T_{BM} - time expended by VM for processing the information,

$T_{\text{пи}}$ - time of transmission of exchange information (i.e., basic information),

$T_{кор}$ - time of correction, determined by requestions of code blocks distorted by interferences.

The general formula for reaction time of the system $T_{р.с}$ will be

$$T_{р.с} = \mu_1' \left[1 + \frac{a'm}{2(1-a')}\right]. \qquad (9)$$

For calculation of the total time of transmission $T_{пд}$ and correction $T_{кор}$ let us use the diagram on Fig. 3 b. From the diagram we see that with detection of error in the received information the opposite signal "incorrect" (GP) is transmitted and repeated - information block. The average length of the information block (in bits) is:

$$N_и = n_с + n_и + n_{к.с} + n_{кр}, \qquad (10)$$

where $n_с$ - number of digits of "start" code,

$n_и$ - average number of information digits,

$n_{к.с}$ - number of digits of code "end communication",

$n_{кр}$ - number of correcting digits.

Delay in the transmission of repeated communication ΔN:

$$\Delta N = n_{обр} + 2\Delta t_{зап} v_{\mu}, \qquad (11)$$

where $n_{обр}$ - number of digits of inverse signal GP ("incorrect"),

$\Delta t_{зап}$ - time of delay in the communication channel,

$v_{и}$ - transmission speed, baud.

In order to determine the transmission time, let us use the value of the equivalent number of digits $N_{эп}$, obtained taking into account the absence of limitations of the number of requestionings in direct channel

$$N_{эп} = N_{и} + (N_{и} + \Delta N)P_{ош} + (N_{и} + \Delta N)P^2_{ош} + \ldots, \quad (12)$$

where $P_{ош}$ - probability of error in the information block.

Having converted this expression, we obtain:

$$N_{эп} = \frac{N_{и} + \Delta N \cdot P_{ош}}{1 - P_{ош}}. \quad (13)$$

If the signal of the inverse channel is not understood, there is accomplished transmission of the "start" signal and two feedback signals. The equivalent number of digits in the inverse channel $N_{эо}$ will be equal to

$$N_{эо} = \frac{3\Delta N}{1 - P'_{ош}}, \quad (14)$$

where $P'_{ош}$ - probability of error in the feedback signal.

It is possible to accept that errors in direct and inverse channels are independent, then the total number of equivalent digits $N_э$ will be equal to

$$N_э = N_{эп} + N_{эо} \qquad (15)$$

The technical speed of transmission V_T is determined from expression

$$V_т = \frac{n_н \cdot V_н}{N_э}. \qquad (16)$$

The sum of the time of transmission and correction will be equal to

$$T_{пд} + T_{кор} = N_э V_н. \qquad (17)$$

In order to determine $N_э$, it is necessary to calculate $P_{ош}$ and $P'_{ош}$.

During determination of the probabilities of errors on the actual communication channels it is possible to use the approximation of the model of channel [3], from which it follows that

$$P_{ош} = 1 - (1 - P_о)^{n^{1-\alpha}}, \qquad (18)$$

where $P_о$ probability of distortion of sending,

n - number of digits in a signal,

α - coefficient of correction between errors, changing from zero with independent errors to 1 with completely correlated errors. With $n^{1-\alpha}\cdot P_0 \ll 1$ the expression for $P_{\text{ош}}$ can be simplified, having written it in the form

$$P_{\text{ош}} = n^{1-\alpha}\cdot P_0. \qquad (19)$$

As a result we obtain the general formula for calculation of $T_{\text{вх}}+T_{\text{кор}}$ taking into account direct and inverse transmission:

$$T_{\text{вх}} + T_{\text{кор}} = 2V_{\text{м}}\left[\frac{(N_{\text{и}} + \Delta N\cdot N_{\text{и}}^{1-\alpha}\cdot P_0)}{1-N_{\text{и}}^{1-\alpha}\cdot P_0} + \right.$$
$$\left. + \frac{3\Delta N}{1-n_{\text{обр}}^{1-\alpha}\cdot P_0}\right]. \qquad (20)$$

Using formulas (8), (9) and (20), it is possible to determine the reaction time of the system taking into account the intensity of the flow of orders, degree of concentration, average length of code combination, speed of transmission, effect of interferences in the communication channel on the speed of transmission. The results of calculation should be the solution of inequality

$$T_{\text{р.с}} \leqslant T_{\text{р.с.з}},$$

where $T_{\text{р.с.з}}$ - assigned reaction time of the system.

Submitted 13 Nov. 1969.

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